

Coastal Processes and Terrain

Chapter 20

Impact of Waves and Currents on the Landscape

- Affect only a tiny fraction of the total Earth's surface
- Create a landscape almost totally different from any other
 - Waves are agents of erosion
 - Currents are agents of transportation and deposition
 - Notable land features
 - Rocky cliffs, headlands, beaches, and sandbars
- Beaches the transition between shoreline and water

Coastal Processes

- Coastlines extend for hundreds of thousands of kilometers.
- Every kind of structure, relief, and topography can be found along coastlines
- Distinctiveness of the coastal milieu
 - Interface three major components
 - Lithosphere, hydrosphere, and atmosphere
 - Dynamic and highly energetic, restless motions of the waters
- Along with water, **wind** has greater influence on the topography because surface of a large body of water can be deformed abruptly and rapidly by wind action.
- The deformation of water surface creates waves and ocean currents
 - Shapes the coastlines
 - Produces topographic features found around the world
- Daily Tidal - fluctuations move enormous amounts of water
- Diastrophic (like Earthquakes) – contribute to water motion
- Long term variations in sea or lake level caused by tectonic forces
- Ecstatic sea-level- decrease or increase in sea level, in the world oceans
- Exceptions to these processes
 - Along lake shores, ranges in tides too small and insignificant to landform development
 - Causes of sea-level fluctuations are quite different from the causes of lake level fluctuations
 - Coral reefs are built only in tropical and sub-tropical oceans, not in lakes

Waves

- Wave Motion
 - The form of the wave as it moves through the water
 - Water itself shifts only slightly
 - In shallow water waves crests and breaks
 - Wind generates most waves
 - Set in motion largely by the friction of air blowing across the water
 - This is a transfer of energy from the wind to the water
- Two Major Kinds of Waves
 - **Water waves (called “forced waves”)**
 - Generated by wind stress on the water surface
 - Develop into considerable size and turbulence
 - Limited existence and don't travel far
 - **Swells**
 - Waves that escape the influence of the generating wind
 - Travel enormous distances
 - Small number of waves not caused by wind
 - Tidal Surge
 - Volcanic Activity

Waves of Oscillation and Transition

- At a given point on top of water surface there is a point of oscillation
 - Oscillation – move back and forth over one place
 - These are Waves of Oscillation
- Resulting from horizontal movement of the surface water
 - These are Waves of Transition

Parts and Measurements of Waves

- As Wave moves forward a Crest is formed
- Followed by the Wave Trough
- Distance between crest to crest is the Wavelength
- Vertical distance from top of crest to bottom of the trough is the Wave height
- Height of a wave depends on
 - Wind speed
 - Wind duration
 - Water depth
 - Fetch (area of open water)
 - Wave amplitude- 1/2 the height of the vertical distance from still water either to the crest or the trough

- Waves often travel great distances across deep water with little change in the shape or speed
- BUT when a wave reaches shallow water changes happen:
- When water depth becomes equal to half the wave length, wave motion begins to be effected by the frictional drag or the sea bottom

Waves of Transition

- Results in horizontal movement of the surface water
- Friction retards the movement
 - **Waves bunch together**
 - **Decrease in wave length**
 - **Height increases**
 - **Drag increases- until instability**
 - **Wave breaks – resulting in**
 - Whitewater surf
 - Plunging forward as a breaker
 - Surging up the beach without cresting
- After breaking the water becomes turbulent – Swash washes up the shore
- Carries sand and rock particles onto the beach or rocky headlands or sea cliffs
- The reverse of Swash is called Back Wash

Wave Refraction

- Where waves change direction
 - Happens when waves do not approach a shore exactly parallel
 - Part of the wave arrives sooner- slows faster and “bends” the wave
 - Tends to smooth the coastal outline by wearing back the headlands and increasing sediment accumulation in the bays

Wave Erosion

- Notable coastal erosion caused by wave action
 - Incessant pounding of the waves wears away the shoreline
 - Speed coupled with mass of water and rock particles
 - Another dimension of wave erosion- air is forced into cracks
 - Pneumatic action is often very effective
 - Chemical action also is effective erosion
 - Dissolves some rocks

Wave Erosion

- Cliffs
 - Most effective erosion takes place just above sea level
 - Clift face retreats slope above
 - Undercut slope collapse
 - Resulting debris is broken, smoothed and made into smaller pieces by further wave action
- Tsunami
 - Sudden disruption of the ocean floor
 - Entire water column is disrupted by uplift of ocean floor
 - Nearing the shore line wave length is decreased and the wave height is increased
 - Rapid advancing surge of water up to 40 meters high
- Tides
- Significant agents of erosions in only:
 - Narrow bays
 - Shallow seas
 - Passages between islands where strong currents scour the sea bottom and cliffs and shorelines

Changes in Sea Level & Lake Level

- Changes can result from either uplift or sinking of land mass (tectonic caused)
- OR increase/decrease in amount of water in the oceans
 - Eustatic Sea Level Change
- Global Warming and Sea level changes
 - What will it do to the world's coast lines if the ice caps of Antarctica and Greenland melt?
 - Global sea level would rise 80 meters (260 feet)

Ice Push

- Shores of bodies of water that freeze over winter are effected by Ice Push
- Results in contraction and expansion
- Frost wedging from the expanding ice pushed into the shore causes more erosion

Organic Secretions

- Coral polyps live in tropical ocean areas
- Coral reefs are developed from the outer skeletons of these polyps

Stream Outflow

- Outflow of streams and rivers into oceans and lakes feed the sediment in water
- Supply the sediment that is moved by the waves

Currents & Coastal Sediment Transport

- Nearly all movement of sediment along coastlines is accomplished by wave action
- Longshore Currents
 - Water moves roughly parallel to the shoreline
 - Develop just offshore, due to action of the waves striking the coast at a slight angle
- Currents & Coastal Sediment Transport
- Beach Drifting
 - Involves the short distance shifting of sand directly on shore by breaking waves and directly offshore by retreating water
 - Movement is in a zig-zaging movement of particles
 - Move because of the oblique direction of wave hitting the shore

Coastal Deposition

- Although erosion happens on shorelines– Deposition also occurs
 - Maritime deposition is more ephemeral than non-coastal deposits
 - Due to more sand and less stabilization due to vegetation cover
 - Sediment budget must be in balance if the deposit is to stay stable
 - Removal of sand must be offset by additional sand

Coastal Landforms

- Beaches
 - Occupies the transition zone between land and water
 - Backshore – upper part of beach
 - Berms – flattish wave-deposited sediment platform
 - Foreshore- zone regularly covered and uncovered by rise and fall of tides
 - Offshore- zone that is permanently under water
- Spits
 - Growing linear deposit of material attached to the land extending into open water in a down-current direction

- Baymouth Bar – (bay barrier) a spit that progresses across a bay or form a lagoon
- Tombolo – spit shape is caused by conflicting water movements- forms a hook
- Barrier Island
 - A long narrow sandbar built up in a shallow offshore waters
 - Results from the heaping up of debris where long waves begin to break in shallow waters of continental shelves
- Lagoon
 - A body of water between the mainland and a spit or baymouth bar of salty or brackish water
- Human Alterations of Coastal Sediment Budgets
 - Dams built – less sediment reaching mouth of rivers changes beaches
 - Artificial structures built to stabilize beaches – reduces sediment transport down shore
- Approaches to solving Beach problems
 - Dumping tons of sand up-current from beach, doesn't work
 - “Hard” stabilization structures
 - Groin – short wall or dam built from a beach to impede longshore currents and force sand deposition
 - Problem erosion breaks down the groin
 - A field of groins are built
 - Jetties – Built in pairs on either side of a river or harbor entrance
 - Confines the flow of water into a narrow zone
 - Keeping the sand in motion and inhibiting its deposition in the navigation channel

Shorelines of Submergence

- Ancient shorelines – almost all coastlines show evidence of submergence during the last 15,000 years
 - Ria shorelines – Drowning of previous river valleys
 - Produces long estuaries of sea water projecting inland
 - Fjoid Coasts – Coastlines occur where high-relief terrain has undergone extensive glaciations.
 - Deep sheer-walled coastal indentations

Shorelines of Emergence and Erosion

- Associated with tectonic lift
- Clearest topographic result of coastal emergence of shoreline features
 - Wave-cut Cliffs and Platforms
 - Comprises wave cut beaches and wave built terraces
 - Marine Terraces
 - Wave-cut platform is uplifted along tectonic rising coast
 - Coral Coast
 - Coral reefs or other type of coral line formation found around islands in the tropics
 - Critical element in development of coral reefs is a group of anthozoan animals called stony corals.
 - Great Barrier Reef an example
 - Volcanic coral reefs
 - Coral animals accumulate around the volcano
 - As coral increases the volcano sinks
 - When volcano sinks completely the coral reef becomes an atoll